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ROBUST SOFT TEXTILE TRANSFER CASE FOR CONTAMINATED MATERIALS WITH NON-RIGID END TERMINATIONS

[0001] The present continuation-in-part application claims the benefit of United States Patent Application Serial Number 15/688,145 filed on August 28, 2017 which claims the benefit of United States Provisional Application 62/382,313 by the inventors, Paul V. Cavallaro, Andrew W. Hulton, Gregory J. Gudejko and Dustin T. Green and entitled “Robust Soft Textile Transfer Package for Contaminated Materials”.

STATEMENT OF GOVERNMENT INTEREST

[0002] The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

CROSS REFERENCE TO OTHER PATENT APPLICATIONS

[0003] None.

BACKGROUND OF THE INVENTION

(1) Field of the Invention

[0004] The present invention applies to the field of containers used in the transport of biologically or chemically contaminated hazardous contents.

(2) Description of the Prior Art

[0005] Current international standards impose strict requirements on the air transport of biologically and chemically hazardous materials. Existing container solutions are designed for small samples rather than larger contents. The maximum stress and stress distributions in larger containers vary considerably based on the size, shape and wall thickness of the container. While safe shipping requirements are attainable for small scale containers at a given internal pressure; larger scale containers encounter significantly higher stresses at the same internal pressure due to the increased volume of the container.

[0006] Also, significantly greater stresses are developed during drop impact and puncture tests due to the increased content and container weights. Working and shipping standards require a leak-proof seal without an allowance for pressure relief. While the container would likely never need to be re-opened after the insertion of the contaminated contents; ease of use in portability (a low weight) and the time to seal the container (sealing in less than 30 minutes) are desired.

[0007] As such, there is a need to increase transfer container sizes in order to accommodate the safe transport of contaminated human remains and other comparably sized contents. Performance metrics require that the containers be sealable within thirty minutes after the insertion of the contents; be puncture resistant; be leak-proof at a hydrostatic pressure of at least thirty-six pounds per square inch; remain leak-proof after a thirty foot drop when filled with water to at least a ninety-eight percent capacity by volume; be transportable by air and by an industry-sized pallet; prevent rapid decompression without a method for pressure relief; and not exceed two hundred pounds in weight. The requirements for a larger container should also permit the use of multiple material components and layers as well as allow for the re-use or replacement of an enclosed bladder and a fabric cylinder.

SUMMARY OF THE INVENTION

[0008] Accordingly, it is a general purpose and primary object of the present invention to provide a high strength and comparatively high volume impermeable container.

[0009] It is a further object of the present invention to provide a low weight container that can be used for the safe transport of biological and chemically contaminated hazardous contents.

[0010] It is a still further object of the present invention to provide a soft transfer case capable of opening to allow the insertion of contents of eighty-five inches by twenty-four inches by eighteen inches with the contents weighing up to three hundred and thirty-five pounds.

[0011] It is a still further object of the present invention to provide a soft transfer case capable of being leak-proof at a hydrostatic pressure of thirty-six pounds per square inch and to remain leak-proof after a thirty foot drop at zero degrees Fahrenheit on a flat surface and after an approximately three foot drop on a rigid rod.

[0012] In order to attain the objects of the present invention, a robustly constructed container is provided. The container is a soft goods transfer case having a film-laminated, woven synthetic fiber textile exterior layer. The exterior strength layer is a circular woven preform constructed without seams and of continuous warp yarns along a longitudinal axis and continuous weft yarns along a hoop (circumferential) axis. In a final form for use, the soft transfer case is shaped as a soft flexible lay-flat structure similar to a large woven fabric circular air beam.

[0013] To prevent air leakage during operation, the soft transfer case has a molded elastomeric bladder containable within the outer circular woven preform. The fabric layer of the woven preform resists expansion when the interior bladder is inflated. The woven preform resembles an open cylinder, and when assembled with the bladder and end clamps, prevents leakage of fluids and gasses.

[0014] Such a circular woven preform eliminates lengthwise seams and requires only two mechanical terminations - one termination with end clamps at each end of the circular preform. Also, the structural and air-retention functions are not performed on the same layer with strength of the structure provided by the exterior fabric layer of the preform and air(gas)/fluid retention function provided by the bladder enclosed in the preform. The strength of the transfer case and the air/fluid retention function are intentionally decoupled.

[0015] In use, the soft transfer case opens to allow the insertion of significantly larger sized contents of biologically or chemically hazardous materials. After insertion, the transfer case is sealed to protect the materials against drop impact, puncture and rapid decompression. The transfer case will likely never be reopened but is capable of being reopened.

[0016] The transfer case of the present invention is puncture resistant and leak proof at a hydrostatic pressure of at least thirty-six pounds per square inch. The container remains leak-proof after a thirty foot drop at thirty-two degrees Fahrenheit on a flat surface and a greater than three foot drop on a rigid rod having a diameter of one and a half inches. The transfer case is also air transportable and resistant to rapid decompression. Furthermore, the transfer case enables the safe repatriation of biologically or chemically contaminated human remains, animal remains, protective equipment or other material in accordance with existing standards of use.

[0017] A variant of the soft transfer case of the present invention provides soft end terminations formed by fold-over regions at fold lines in the outer textile strength layer. The strength layer is fitted with matching locking or security straps affixed along a longitudinal exterior of the strength layer. The securing straps are locked together with rings, carabineers, cordage or the like. Lifting handles are also affixed to a longitudinal exterior and a circumference of the outer textile strength in order to ease transport of the soft transfer case.

[0018] Ends of the bladder extend outward from fold lines but do not extend to the ends of the outer textile strength layer. That is, each bladder end is contained between an adjacent fold line and a corresponding end of the outer strength layer.

[0019] In use and upon pressurization of the bladder (likely by the contaminated or hazardous material in the bladder); the preform of the outer textile strength layer forms a cylindrical shape that is remote from the ends. Further expansion of the bladder is resisted by tension developed across the locking or security straps.

[0020] Additional locking straps and optional reinforcement layers constructed of fabric or elastomeric materials may be provided to increase the uniformity of the tensile stresses from the locking straps to the ends and body sections of the circular textile preform. One or more longitudinal retention straps or webbings can be added for strength with the straps positioned along a longitudinal perimeter of the textile preform (when in the ends folded configuration) using alignment loops fixed to the textile layer. The alignment loops prevent the longitudinal retention straps from sliding out of position during loading of the soft transfer case.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] Other objects, features and advantages of the present invention will be better understood by means of a detailed description of the drawings that illustrate the principals of the present invention in which:

[0022] **FIG. 1** depicts a dimensioned isometric view of a soft transfer case of the present invention;

[0023] **FIG. 2** is a plan view of the soft transfer case of the present invention with longitudinal retention straps and a mechanical clamping assemblies shown;

[0024] **FIG. 3** is a plan view of a mechanical end clamp used to close the soft transfer case of the present invention;

[0025] **FIG. 4** is a side of the mechanical end clamp of the present invention;

[0026] **FIG. 5** is a detailed view of the weave pattern for the textile outer layer of the soft transfer case of the present invention;

[0027] **FIG. 6A** depicts human remains inserted in the bladder of the soft transfer case of the present invention;

[0028] **FIG. 6B** depicts the bladder of the present invention with human remains inserted and with the bladder closed by sealing;

[0029] **FIG. 6C** depicts the bladder of the present invention inserted in the textile outer layer of the present invention;

[0030] **FIG. 6D** depicts the textile outer layer of the present invention with the mechanical end clamps attached;

[0031] **FIG. 6E** depicts interior pressure vectors on the textile outer layer of the present invention;

[0032] **FIG. 7** depicts a soft transfer case as a variant of the embodiment of the present invention in which the transfer case has non-rigid end terminations;

[0033] **FIG. 8A** depicts human remains inserted in the bladder of the variant of the soft transfer case of the present invention;

[0034] **FIG. 8B** depicts the bladder of the variant with human remains inserted and with the bladder closed by sealing;

[0035] **FIG. 8C** depicts the bladder and outer strength layer folded at both ends of the soft transfer case; and

[0036] **FIG. 8D** depicts the textile outer strength layer of the present invention with securing rings attached.

DETAILED DESCRIPTION OF THE INVENTION

[0037] Referring now to the drawings, and more particularly to **FIG. 1**, a soft transfer case **10** with an outer textile strength layer **12** is shown. The twelve-inch dimension in the figure represents the approximate length of a transition of the transfer case **10** from a cylinder to a tapered geometry at mechanical end clamps **20** when the transfer case is subject to an internal pressure. The ninety-eight inch dimension represents the approximate length of a cylindrical region of the transfer case **10** when the transfer case is subject to internal pressure. A preferred overall length of the transfer case **10** is one hundred and twenty-two inches with a circumference of at least eighty inches.

[0038] As shown in **FIG. 2**, the soft transfer case **10** includes longitudinal retention straps **11** with the transfer case secured by the bolted mechanical end clamps **20** (See **FIG. 3** and **FIG. 4** for additional detail on the end clamps). The longitudinal retention straps **11** are flat webbing, similar to the material of seat belts and can be made of polyester fibers or any other similar structural material. The outer textile strength layer **12** of the transfer case **10** is a continuously woven, circular textile (i.e., Para-aramid synthetic fiber or other high performance fibers) preform layer (See **FIG. 5** for additional detail on the fiber arrangement of the preform layer).

[0039] In operation, the outer textile strength layer **12** reacts against pressurization; confines volumetric expansion of an internal bladder; and prevents puncture and impact damage. The outer textile strength layer **12** is optionally film laminated or surface coated; however, such a film or coating is only used to protect the fibers from environmental effects and is not to act as the primary bladder for pressure retention purposes.

Flexible elastomeric coatings such as urethanes are appropriate for use, provided that the films or coatings behave as flexible membranes. The use of elastomeric films or coatings can be applied to the yarns before weaving or sprayed/brushed on after the soft transfer case **10** is constructed. Laminations are generally only applied to the fabric after weaving.

[0040] As shown in **FIG. 6A-6E**, a layer enclosed by the outer textile strength layer **12** is a separate internal membrane that serves as an oversized (at a size at least fifteen-twenty percent greater than the inflated preform size) impermeable bladder **14** that can provide air retention. The gas/fluid retention member is the oversized bladder **14**, specifically the internal membrane of the bladder. After the bladder **14** is positioned inside the outer textile strength layer **12** and upon inflation of the bladder; the expansion of the internal membrane of the bladder is resisted by the outer textile layer.

[0041] As shown in **FIG. 3** and **FIG. 4**, end terminations for the outer textile strength layer **12** are each a mechanical clamp **20** constructed of three components. The components are a solid rod **22** fitted within a slotted sleeve formed by clamshell plates **24** and secured by retention bolts **26** or other mechanical fasteners. This type of end clamp has been used successfully for strap-reinforced, braided inflatable air beams designed for military shelters.

[0042] Each end of the circular woven preform of the soft transfer case **10** is wrapped over a separate solid rod **22.** The slotted sleeve of a clamshell plate **24** is inserted over each rod **22** to secure the preform. The mechanical clamps **20,** as shown, do not engage and secure the bladder **14.** However, the mechanical clamps **20** can be optionally designed to simultaneously secure the bladder **14** and the outer textile strength layer **12.**

[0043] Upon pressurization of the bladder **14,** the preform of the outer textile strength layer **12** develops a cylindrical form (remote from the ends), as shown by the twelve inch measurements in **FIG. 1,** which then resists further expansion of the internal bladder. The stresses due to inflation are distributed to minimize concentrations and to avoid failures at rip points. This is an important reason for the fabric design approach of the outer textile strength layer **12** in which maximum stresses occur at the cylindrical region and not at the transition or clamped regions.

[0044] A clamping force is generated between the outer textile strength layer **12** and the mechanical clamps **20.** The mechanical clamps **20** apply an increasing restraining force upon increasing internal pressure. As shown in **FIG. 4,** the mechanical end clamp **20** with an optional bonded elastomeric liner **28** assists in reducing stress concentrations in the outer textile strength layer **12** at an interface of the clamp.

[0045] As shown in **FIG. 5**, the preform of the outer textile strength layer **12** is formed by using plain-woven and dense fabric architecture. A circular weaving process produces a right-circular cylinder of the outer textile strength layer **12** with open ends and no seams. Dense implies that the plain weave is tightly woven so that light cannot shine through and that pointed objects will not force the yarns to separate (migrate) away from the point of impact or puncture. Denseness of the textile preform is controlled by the number of warp and weft yarns per unit distance of fabric.

[0046] In a plain woven fabric, the warp yarns cross over and under consecutive weft yarns. Warp yarns are oriented along the longitudinal axis of the formed cylinder of the outer textile strength layer **12** of the soft transfer case **10**. Weft yarns are aligned along the hoop or circumferential direction of the cylinder of the outer textile strength layer **12**. As known in the art, warp yarns are in a longitudinal direction and weft yarns are in a hoop or circumferential direction to form the continuous cylindrical structure of the outer textile strength layer **12**.

[0047] The highly dense, tightly woven fabric achieves a maximum puncture resistance and damage tolerance. A multi-layer warp and weft pattern could be used to provide additional protection against puncture and burst. Fabric density increases with increasing numbers of warp yarns per unit circumference and weft yarns per cylinder length. High density tightly woven fabrics restrict relative yarn motions from occurring such that the interstices (spaces between yarns) remain negligible when the outer textile strength layer **12** is mechanically stressed. If the relative yarn motions are significant; the interstices can become sufficiently large; thereby, exposing the internal bladder **14** to potential punctures and impact damage from sharp or pointed objects.

[0048] Having a six-thousands of an inch diameter for the yarn is preferred but other diameters are possible with testing. Also, the yarns can be coated to minimize damage from weaving and to provide environmental protection when the soft transfer case **10** is used in field operations. A high performance fiber material is recommended for the fabric. PARA-ARAMID SYNTHETIC FIBER is such a material but other materials exist within this category such as Dimensionally Stable Polyester and VECTRAN (a liquid crystal polymer).

[0049] The bladder **14** is molded by using an elastomeric material in a pouch-shaped form having a single open end and is made of elastomeric materials such as urethane, rubber and silicone. The diameter and length of the bladder **14** is approximately ten to thirty percent greater than the diameter and length of the outer textile strength layer **12**. This is important because oversizing the bladder **14** prevents the bladder from being subjected to stress when the soft transfer case **10** is pressurized.

[0050] Silicone is one of many choices but urethanes can also be used. The selected material of the bladder **14** will be, in general, based upon compatibility with gasses and fluids that are contained in the soft transfer case **10**. The elastomeric material must meet the biological and chemical resistance requirements. Silicone and other materials options exist, including thermoplastic urethane.

[0051] After molding, the open end of the bladder **14** is rolled up on itself to allow easy insertion of the contaminated materials inside the container. The bladder **14** requires only one seam which is used to permanently seal the open end. Seaming can be done at the point of use by a variety of known methods including heat sealing, adhesive bonding and RF welding.

[0052] More specifically, the sequence of operation is illustrated in **FIGS. 6A-6E** in which the bladder **14** is received for field use in a rolled up configuration. As shown in **FIG. 6A**, the contaminated contents (or human remains) are placed inside the bladder **14** as the bladder is unrolled or after the bladder is unrolled – depending on whatever is easier for the operator or the size of the remains. As shown in **FIG. 6B**, the bladder **14** is then sealed along the single open end seam and remains unstressed at an ambient pressure (i.e., $p_{internal} = p_{external}$). As shown in **FIG. 6C**, the bladder **14** with contents is inserted within the outer textile strength layer **12** and in **FIG. 6D**, the mechanical clamps **20** are attached with a seam of the outer textile layer folding over the bladder. The strength of the mechanical end clamps **20** is greater than the strength of the outer textile strength layer **12** to ensure that the outer layer will fail first.

[0053] During air transport, rapid decompression of a closed container can be a dangerous event and must not occur. When using the soft transfer case **10** at high altitudes; a pressure differential can develop such that the bladder **14** becomes internally pressurized as $p_{internal}$ is greater than $p_{altitude}$. The bladder **14** expands with the preform of the outer textile strength layer **12** but does so without stretching. The outer textile strength layer **12** then becomes biaxially stressed along the longitudinal and circumferential directions of the fabric; resists further expansion of the bladder **14**; and develops a shape that achieves static equilibrium. Static equilibrium is achieved when inflation causes the soft transfer case **10** to develop biaxial stress states so that a stationary or stable configuration (geometry) does not experience any dynamical effects (flutter, vibration, etc) is produced. The bladder **14** remains unstretched in the presence of the remaining preform with no stresses developed within the bladder.

[0054] The preform of the outer textile strength layer **12** resists the bladder **14** from freely expanding. If the bladder **14** is oversized for the volume contained by the outer textile layer **12** then the bladder cannot be subject to stress. The bladder **14** is restricted from straightening out to a full shape by the outer textile or fabric strength layer **12.** If the bladder **14** cannot completely straighten out; then the bladder cannot stretch and therefore the bladder cannot experience strain or stress.

[0055] Upon pressurization of the bladder **14,** the preform of the outer textile strength layer **12** expands and a mechanical restraining force is generated between the textile layer and the mechanical clamps **20.** When the bladder **14** is designed not to be secured to the mechanical clamps **20;** the bladder simply conforms to the presence of the rod **22.**

[0056] Several advantages using the chemically/biologically resistant soft transfer case **10** of the present invention include: the decoupling of the structural and air retention functions by utilizing physically and distinct separate layers;

the use of an oversized elastomeric bladder **14** that, when inserted inside the smaller outer textile strength layer **12**, expands without stretching and therefore does not experience stress with internal pressurization such that air retention performance of the bladder and single seam remain independent of internal pressure; the use of soft good components such as the structural and bladder elements that enable roll-form delivery to point-of-use.

[0057] The outer textile strength layer **12** is used as a compliant structural layer that minimizes system weight and that minimizes stress from pressurization (the peak stresses are remote from the ends with stress distributions uniformly distributed remote from the ends). The stresses from drop impacts are less than those produced in conventional rigid structures.

[0058] Also, the soft transfer case **10** of the present invention utilizes a woven fabric having orthogonally arranged fiber placement such that the fabric resists lengthwise expansion directly by the longitudinal fibers and therefore does not require the use of tension strap reinforcements although the longitudinal straps **11** are preferably used.

[0059] The structural benefits of using a circular woven material for the outer textile strength layer **12** is that upon pressurization, a cylindrical shape is developed and bi-axial stresses are uniformly distributed and remote from the ends. Furthermore, the maximum tensile stress is located in the cylindrical portion of the shape away from the clamped ends and localized stress concentrations and a 2:1 ratio of circumferential to longitudinal stress per unit distance is produced.

[0060] Another major advantage of the soft transfer case **10** of the present invention is that the outer textile strength layer **12** can be supplied to the field in roll form. Rolling the outer textile strength layer **12** will minimize logistics, inventory and supply control activities. The proper length of the preform outer textile strength layer **12** can be unrolled and cut to the required length for further use.

[0061] A variant soft transfer case **100** is shown in **FIG. 7**. Unlike the soft transfer case **10**, the variant soft transfer case **100** does not use a rigid clamping device as an end termination.

[0062] The first layer of the soft transfer case **100** is an outer textile strength layer **102** comprised of a continuously-woven or braided circular textile preform of high performance fibers. The outer textile strength layer **102** is designed to react against pressurization; confine volumetric expansion of an enclosed and internal bladder **104**; and to provide resistance to punctures and impact damage.

[0063] The outer textile strength layer **102** can be film-laminated or surface-coated. However, such a film or coating is only used to protect the fibers from environmental effects and is not intended to act as the primary bladder for pressure retention purposes.

[0064] The internal bladder **104** can provide air or fluid retention. The bladder **104** can be made of elastomeric materials such as urethane, rubber, silicone, etc. The ends of the bladder **104** extend outward from fold lines of the fold-over regions but do not extend to the ends of the outer textile strength layer **102.** That is, each end of the bladder **104** is contained between an adjacent fold line and the corresponding end of the outer textile strength layer **102.**

[0065] Soft end terminations are formed by fold-over regions fitted with matching locking straps **106** affixed to open ends of the outer textile strength layer **102** as well as in proximity to and on opposite sides of a midpoint axis of the outer textile strength layer. Lifting handles **108** extend in a different direction or circumferentially from the outer textile strength layer **102** as compared to the longitudinal direction of the locking straps **106** on the outer textile strength layer. Additional lifting handles **108** extend from fold-over regions of the soft transfer case **100** as will be shown and referred to in the use of the soft transfer case.

[0066] The locking straps **106** are mechanically locked together with rings, carabineers, cordage or the like. The use of soft end terminations is particularly advantageous because the soft transfer case **100** is lighter, less costly and replaces the need for heavy and rigid bar/end clamp device and associated longitudinal reinforcement straps.

[0067] In use and upon pressurization of the bladder **104**, the textile preform develops a cylindrical shape that is remote from the ends of the soft transfer case **100**. The textile preform resists further expansion of the internal bladder **104** by the tension developed across the locking straps **106**. Additional locking straps can be added and optional reinforcement layers constructed of fabric or elastomeric materials may be provided to increase the uniformity of the tensile stresses from the locking straps **106** to the ends and body sections of the circular textile preform of the soft transfer case **100**.

[0068] Additionally, one or more longitudinal retention straps or webbing (not shown) can be used for added strength. These retention straps can be positioned along the longitudinal perimeter of the textile preform (when in the ends-folded configuration) using alignment loops affixed to the outer textile strength layer **102**. The alignment loops prevent the longitudinal retention straps from sliding out of position during loading events.

[0069] The circular textile preform of the soft transfer case **100** is fabricated using a woven and highly dense fabric architecture. Denseness of the preform is controlled by the number of warp and weft yarns per distance of fabric. Warp yarns are oriented along the longitudinal axis of the soft transfer case **100** and weft yarns are aligned along the hoop or circumferential direction of the soft transfer case.

[0070] A highly dense, tightly woven fabric is used to achieve maximum puncture resistance and damage tolerance. Fabric density increases with increasing numbers of warp yarns per unit circumference and weft yarns per unit cylinder length. High density tightly woven fabrics restrict relative yarn motions from occurring such that the interstices (spaces between yarns) remain negligible when the preform is subjected to penetration by pointed impactors or other sharp objects. If the relative yarn motions are significant, the interstices can become sufficiently large thereby exposing the internal bladder to potential punctures and impact damage.

[0071] The bladder **104** is molded using an elastomeric material with open ends. The elastomeric material must meet the prescribed chemical and biological resistance requirements for the contents being transported. The bladder **104** requires two seams with each seam adjacent to each end of the preform of the soft transfer case **100**. Sealing of the ends of the bladder **104**

can be accomplished by a variety of methods including heat sealing, adhesive bonding, welding, etc.

[0072] More specifically, the sequence of operation is illustrated in **FIGS. 8A-8E** in which the bladder **104** is received for field use in a rolled up and cut-for-length configuration. As shown in **FIG. 8A**, the contaminated contents (or human remains) are placed inside the bladder **104** as the bladder is unrolled or after the bladder is unrolled – depending on whatever is easier for the operator or depending on the size of the remains. As shown in **FIG. 8B**, the bladder **104** is then sealed along the open end seams and remains unstressed at an ambient pressure with the contents inserted within the outer textile strength layer **102**. In **FIG. 8C** and **FIG. 8D**, the soft transfer case **100** is then folded along the designated fold lines and the locking straps **106** are secured together using rings (carabineers) **110** to contain the bladder **104**. The lifting handles **108** are then used to ease the transport of the soft transfer case **100**.

[0073] During air transport, rapid decompression of a generally large and closed container can be a dangerous event and must not occur. Considering the soft transfer case **100** at high altitudes, a pressure differential can develop such that the bladder **104** becomes internally pressurized. The oversized bladder **104** expands within the outer textile strength layer **102**

but does so without stretching. The textile preform becomes bi-axially stressed, resists further bladder expansion and develops a shape that achieves static equilibrium.

[0074] Because the oversized bladder **104** remains unstretched at all times in the presence of the restraining textile preform; no in-plane stresses are developed in the bladder. The textile preform of the outer textile strength layer **102** prevents the bladder **104** from fully straightening such that the bladder is not permitted to stretch. Upon pressurization of the bladder **104**, the textile preform expands and a mechanical restraining force is generated between the preform and the locking straps by the mechanical rings, carbineers, cordage, etc.

[0075] Advantages of the soft transfer case **100** include: the decoupling of the structural and air (fluid or solid) retention functions by the use of physically and distinctly separate layers; the use of an oversized elastomeric bladder that, when inserted into the smaller textile preform of the outer strength layer, expands without stretching and therefore does not experience in-plane stress with internal pressurization such that air retention performance of the bladder and end seams remains independent of internal pressure; the use of soft-good components such as the structural and bladder elements enables roll-form delivery to point-of-use; and the use of a circular textile preform as a compliant structural layer that minimizes weight, minimizes stress from pressurization (peak stresses are remote from the ends such that stress distributions are uniformly distributed remote from the ends), and stressed developed during drop impact events are less than those produced within conventional rigid structures.

[0076] The soft transfer case **100** utilizes a continuously circular woven fabric preform having orthogonally arranged fiber placement such that lengthwise expansion is directly resisted by the longitudinal fibers and therefore does not require the use of tension strap reinforcements to resist longitudinal tensile stresses developed by internal pressurization. Furthermore, the soft end termination capability of the soft transfer case **100** eliminates the bulkiness and weight of rigid clamping and therefore allows for faster field processing and operations without the need for tools.

[0077] The textile preform of the outer textile strength layer **102** can be fabricated using a variety of seamless textile fabric architecture (plain, twill, satin-woven, etc.) and fiber materials such as but not limited to nylon, ultra-high molecular weight polyethylene, polyester, liquid crystal polymer, etc. For increased burst and puncture strengths and improved resistance to environmental effects; the circular textile preform may be constructed of multiple layers of identical or different textile architectures and materials.

[0078] The internal oversized bladder **104** can be molded from various elastomers such as urethane, rubber, silicone, etc. provided that the material is compatible for containing the contaminated agents. The ideal bladder seaming process will depend on the selected bladder material but methods include adhesive bonding, heat sealing, RF welding and others may be suitable.

[0079] Additional fabric or elastomeric reinforcement layers may be locally employed in the vicinity of the fold-over regions to improve the distribution of the locking strap tension forces over the fold-over ends and body portions of the textile preform. A single longitudinal retention strap or multiple longitudinal retention straps can be optionally used to provide additional support to the locking straps. Other methods for securing the locking straps together beyond the mechanical rings, carabineers, and cordage may include stitching, riveting, bonding etc. of the locking strap pairs.

[0080] The soft transfer case **100** has the ability to support multiple bladders for different hazardous materials within a single transfer package. The soft transfer case is scalable and capable of use across many industrial, commercial, consumer and military markets. The soft transfer case provides further utility for use as towable bladders (also known as dracone barges) for sea transport of bulk fluids.

[0081] Yet another use of the soft transfer case is as a deployable and flexible escape pod for use by undersea divers, astronauts, emergency responders, marine workers, etc. When used as an escape pod, the bladder is filled with air and optional scuba tanks to enable the safe and short-term transport of one or more occupants.

[0082] It will be understood that many additional changes in the details, materials, steps and arrangement of parts, which have been herein described and illustrated in order to explain the nature of the invention, may be made by those skilled in the art within the principle and scope of the invention as expressed in the appended claims.

[0083] The foregoing description of the preferred embodiments of the invention has been presented for purposes of illustration and description only. It is not intended to be exhaustive nor to limit the invention to the precise form disclosed; and obviously many modifications and variations are possible in light of the above teaching. Such modifications and variations that may be apparent to a person skilled in the art are intended to be included within the scope of this invention as defined by the accompanying claims.

ROBUST SOFT TEXTILE TRANSFER CASE FOR CONTAMINATED MATERIALS WITH NON-RIGID END TERMINATIONS

ABSTRACT OF THE DISCLOSURE

A soft transfer case for contaminated material is provided. The transfer case includes a film-laminated, woven textile exterior layer as a pouch. The cylinder is capable of being clamped at each end of the cylinder. An open end elastomeric bladder for containing the contaminated material is contained by the exterior layer. The bladder includes a seam to seal the open end with the material contained therein. Upon pressurization of the bladder, the exterior layer expands and a restraining force is generated between the textile layer and the clamps. A variant of the soft transfer case provides soft end terminations formed by fold-over regions at fold lines in the exterior layer. The exterior layer is fitted with matching locking straps affixed along a longitudinal exterior. The locking straps mechanically lock together. Lifting handles are also affixed to the exterior strength layer to ease transport of the transfer case.

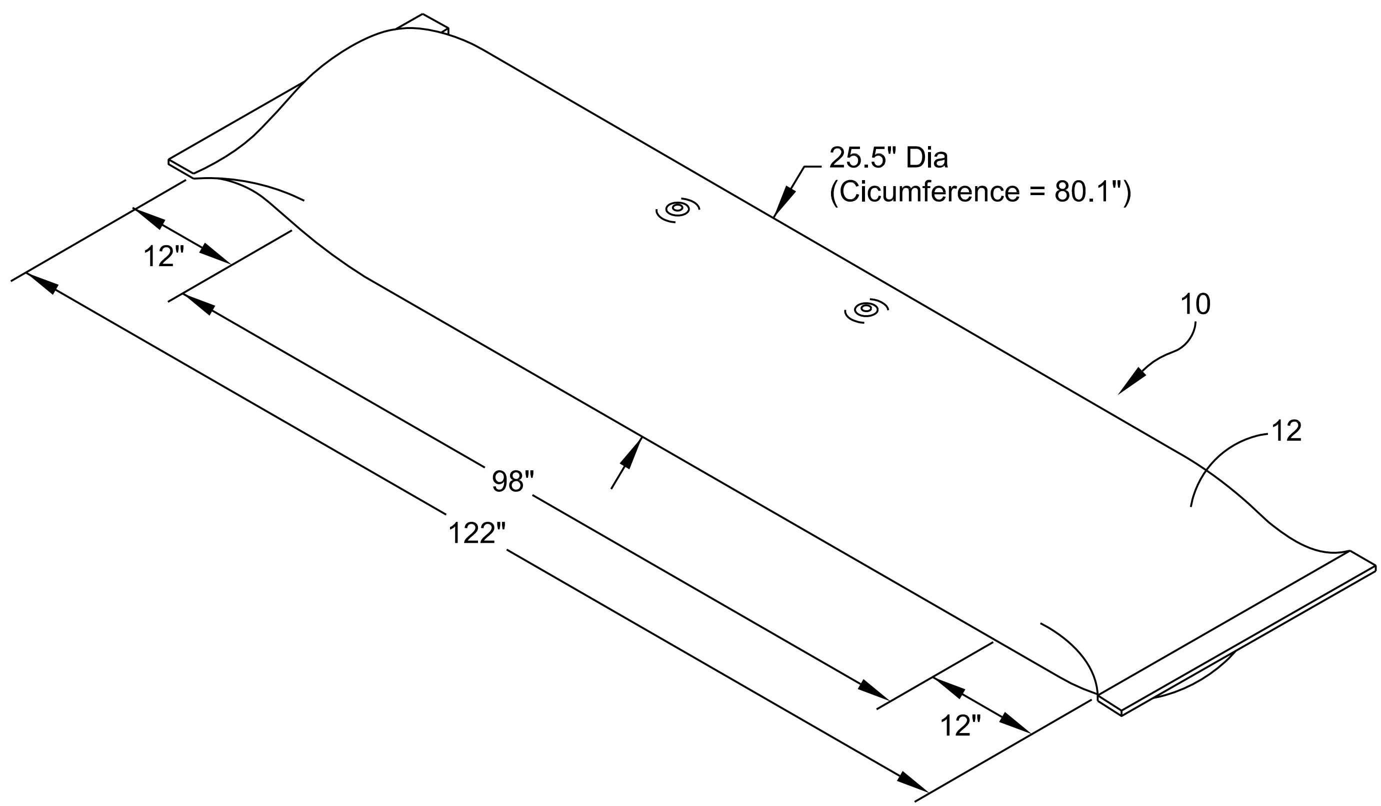


FIG. 1

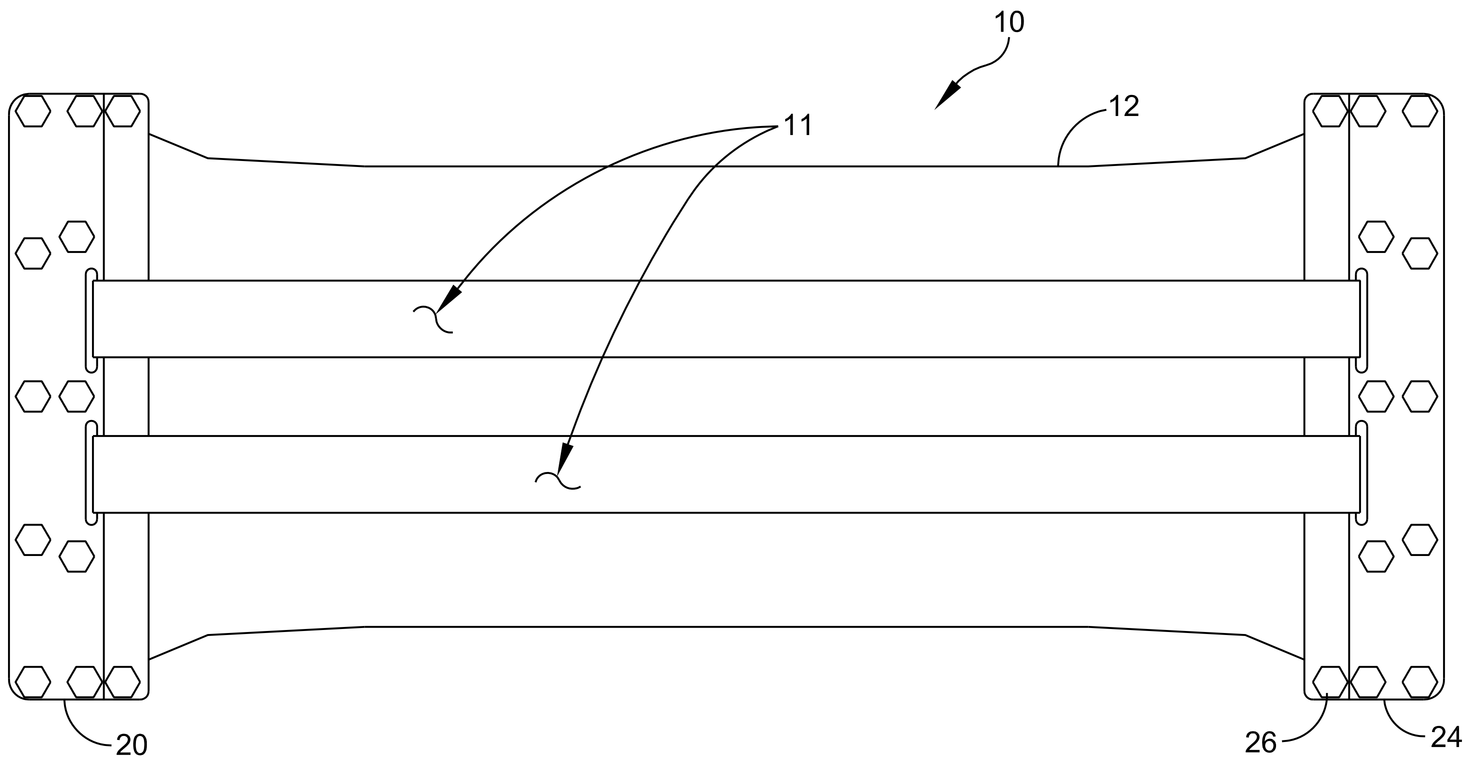


FIG. 2

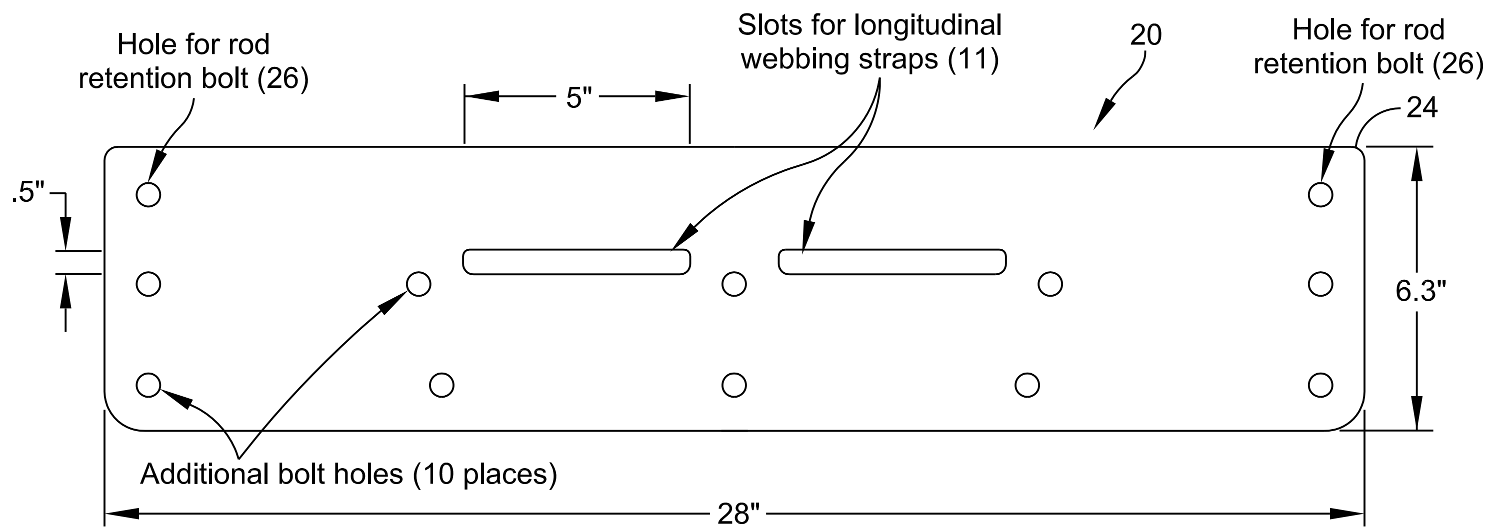

Hole for rod
retention bolt (26)
5"
Slots for longitudinal
webbing straps (11)
20
Hole for rod
retention bolt (26)
24
.5"
6.3"
Additional bolt holes (10 places)
28"

FIG. 3

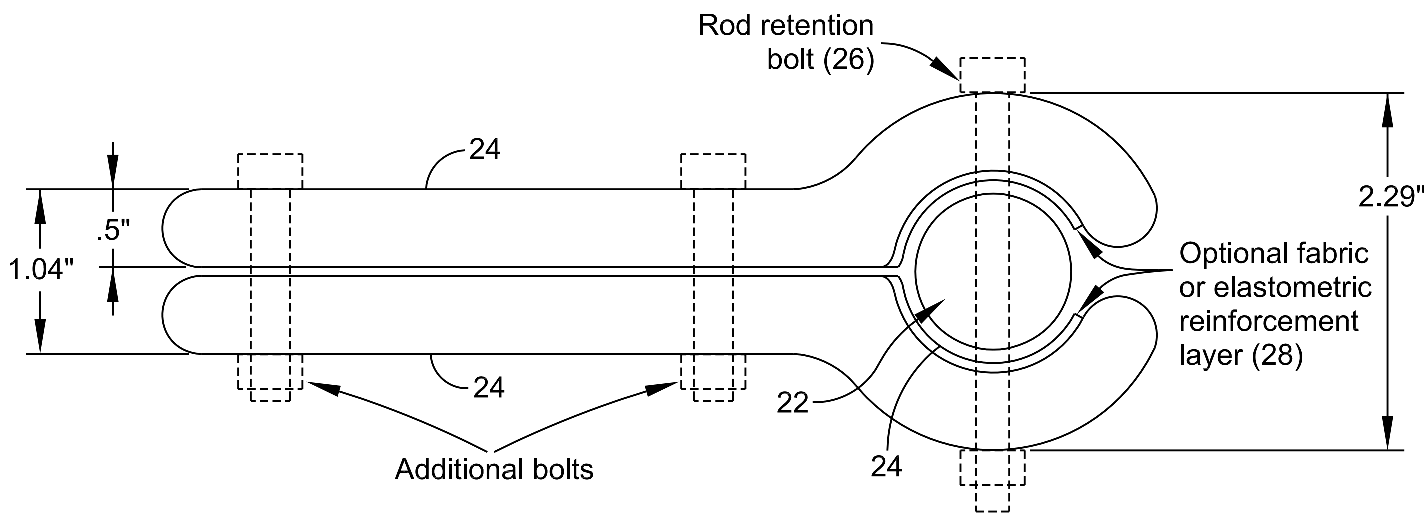
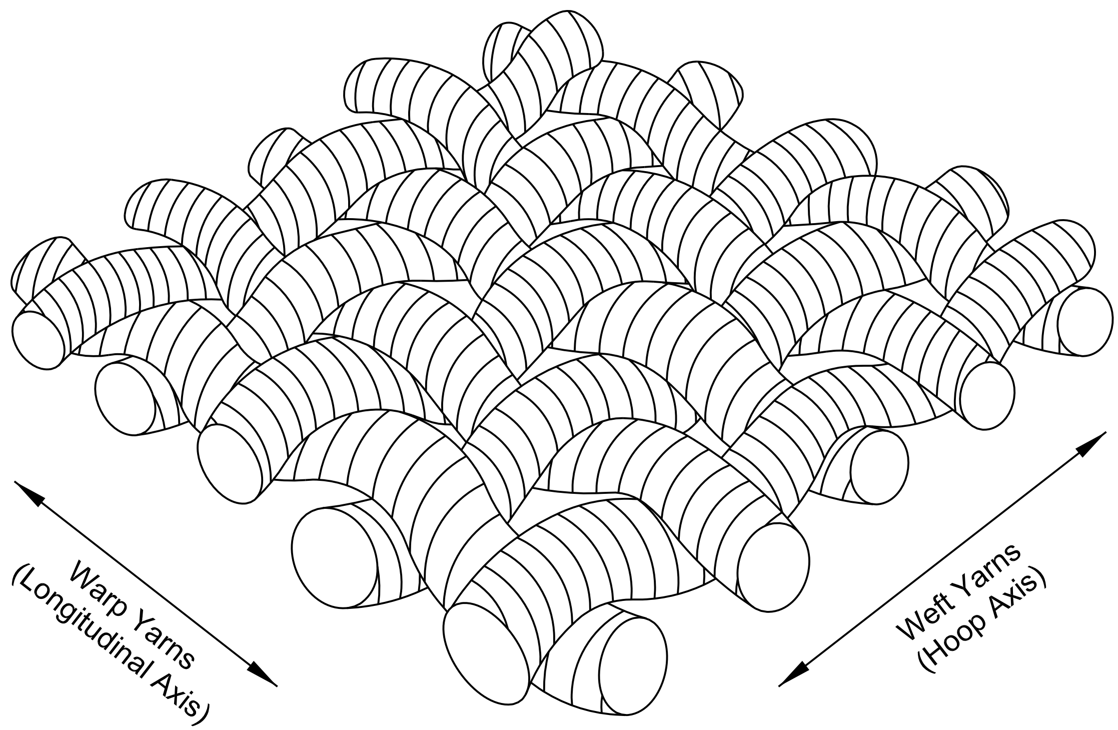

Rod retention bolt (26)
24
.5"
1.04"
2.29"
Optional fabric or elastometric reinforcement layer (28)
24
22
24
Additional bolts

FIG. 4



Plain Woven Fabric

FIG. 5

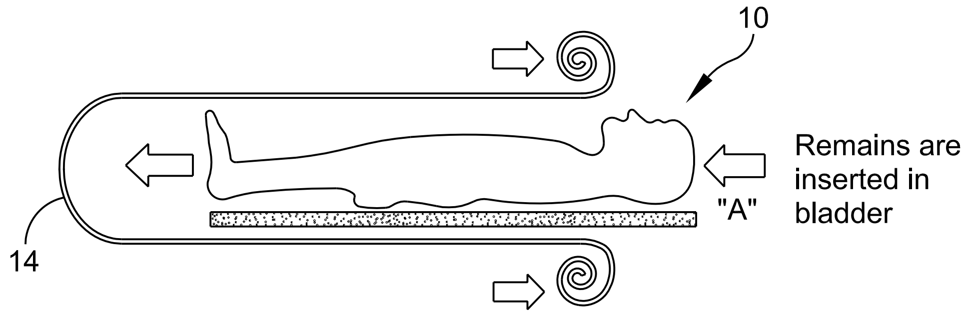


FIG. 6A

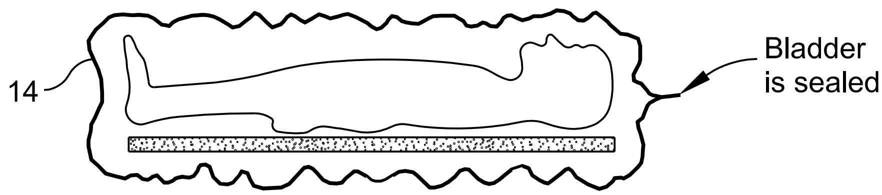


FIG. 6B

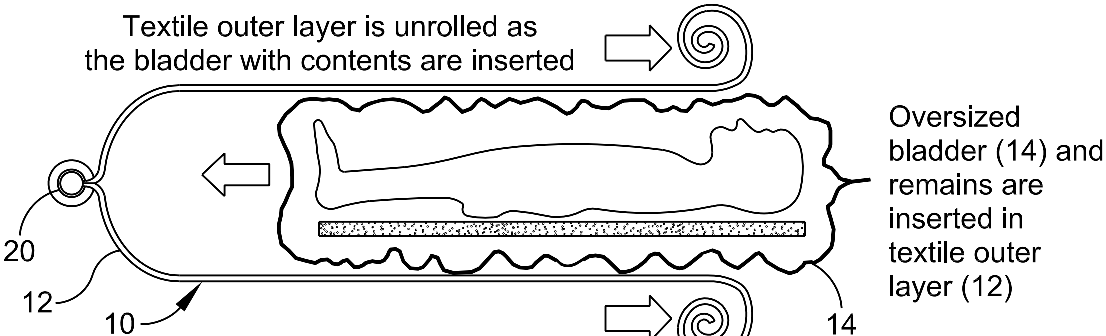


FIG. 6C

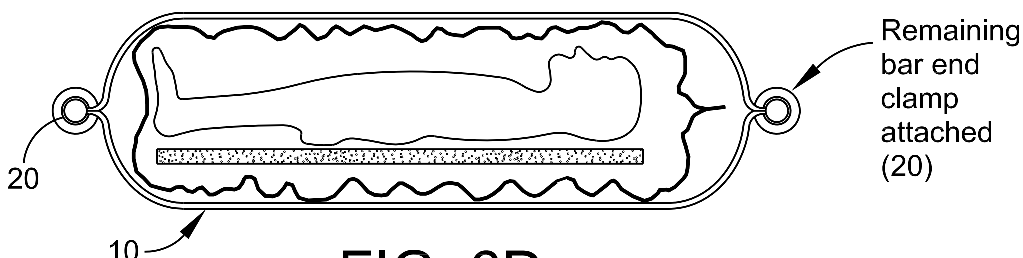


FIG. 6D

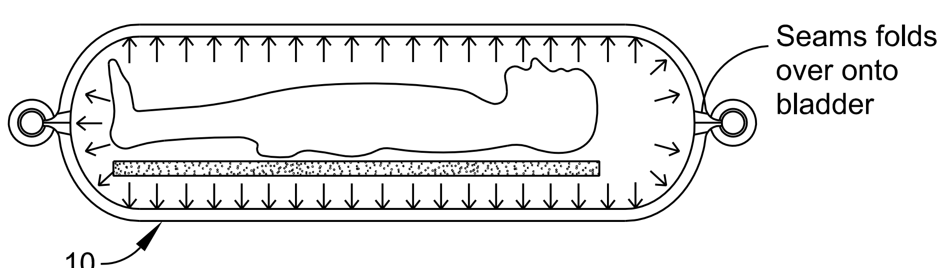


FIG. 6E

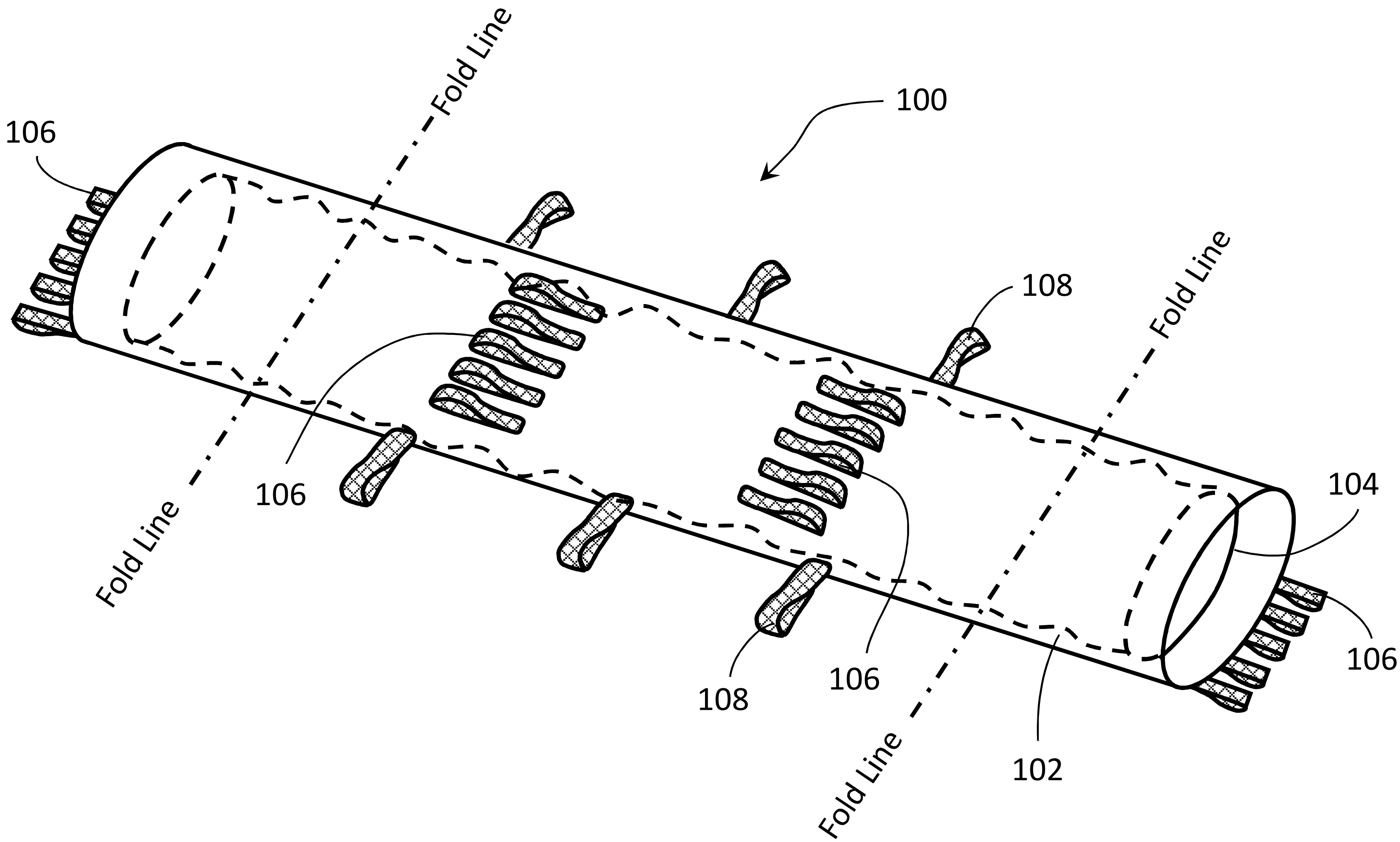
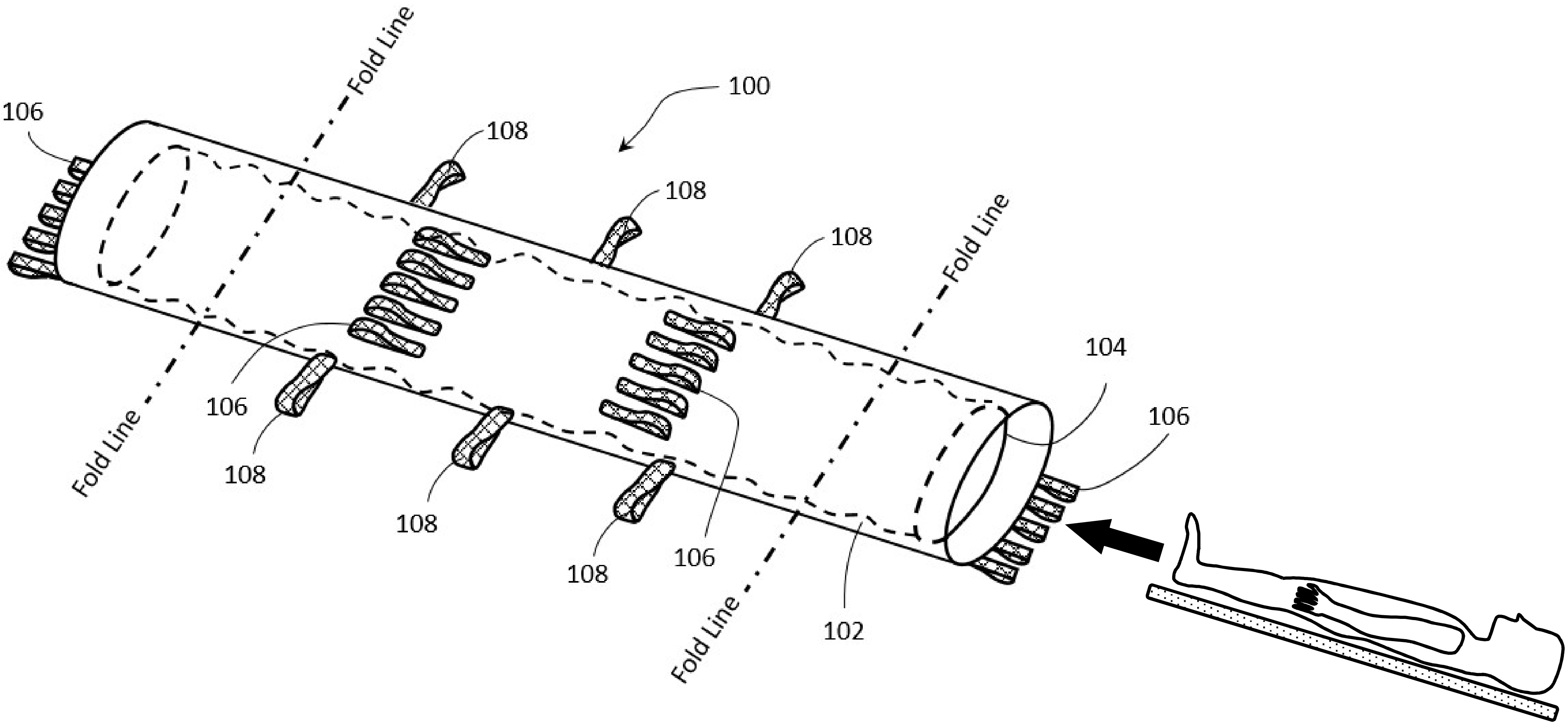

100
106
Fold Line
108
Fold Line
106
Fold Line
104
106
108
106
Fold Line
102

FIG. 7



106
Fold Line
100
108
108
108
Fold Line
106
Fold Line
108
108
108
104
106
106
Fold Line
102

FIG. 8A

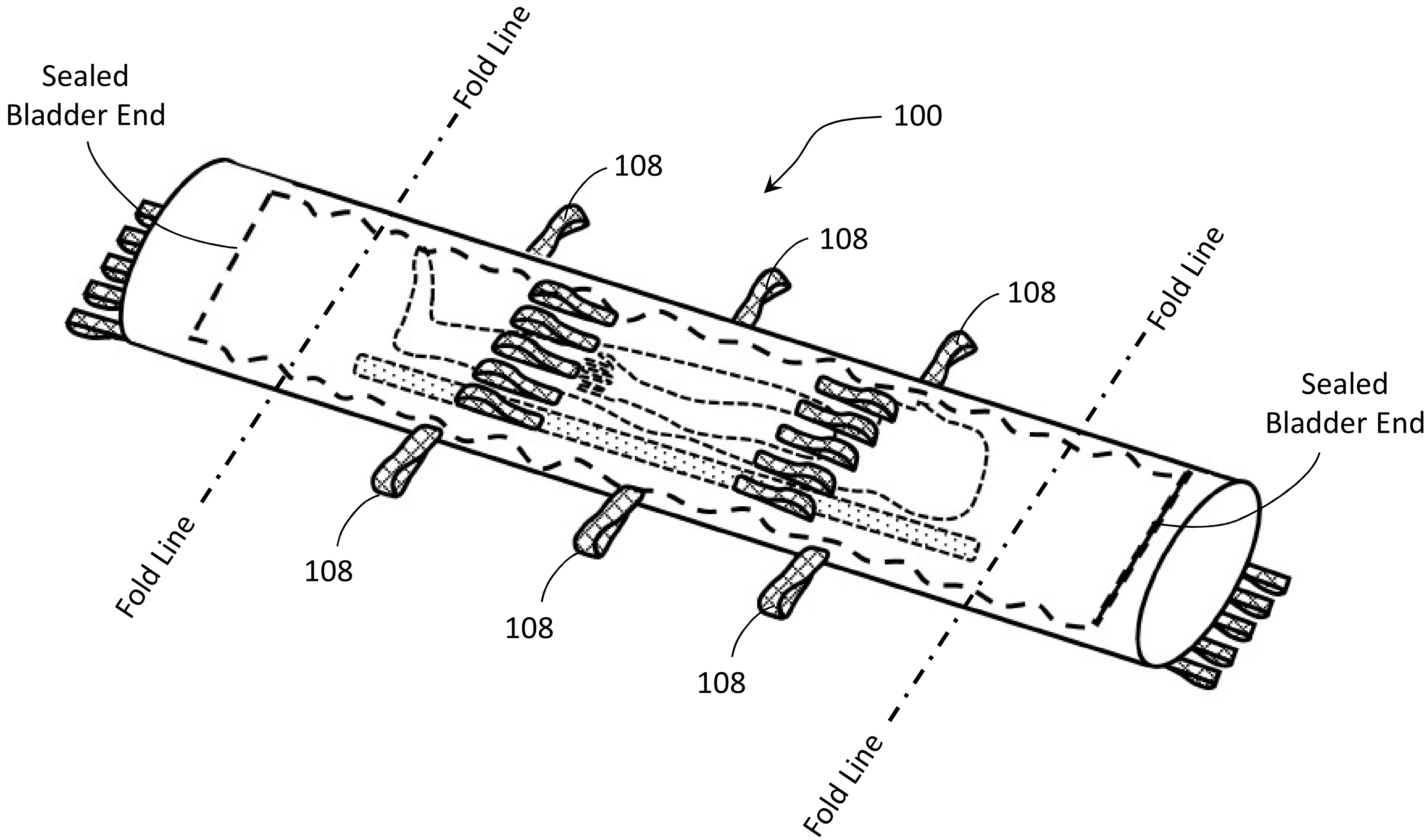
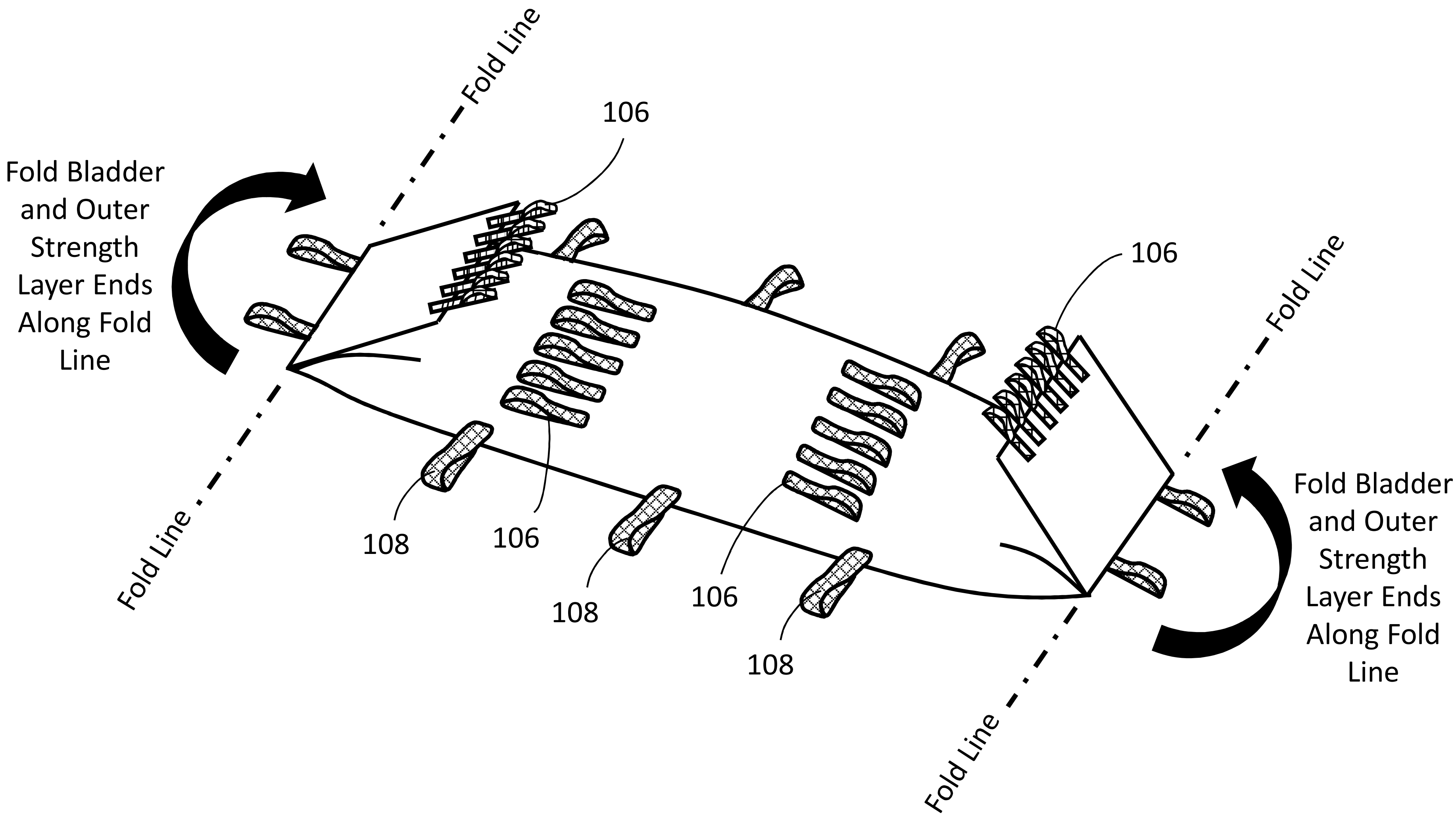

Sealed
Bladder End
Fold Line
100
108
108
108
Fold Line
Sealed
Bladder End
108
108
108
Fold Line
Fold Line

FIG. 8B



Fold Bladder and Outer Strength Layer Ends Along Fold Line
Fold Line
Fold Line
106
106
106
106
106
108
108
108
Fold Line
Fold Line
Fold Bladder and Outer Strength Layer Ends Along Fold Line

FIG. 8C

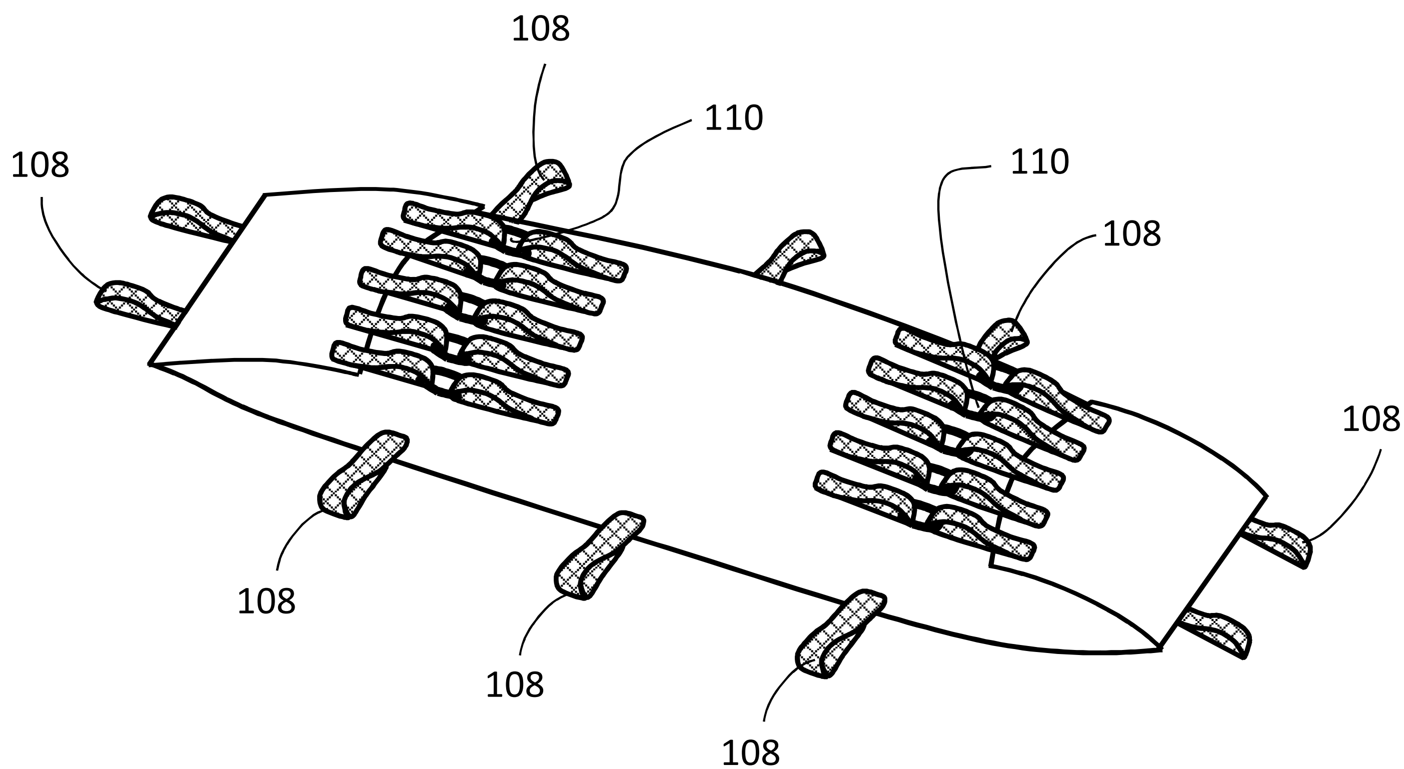


FIG. 8D